Communicating Real-Time and Forecasted Air Quality to the Public

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Air quality forecasts for more than 250 cities in the United States are made daily by state and local air quality agencies and are widely used by print, television, and Internet media outlets to alert the public. To improve the accuracy, reliability, and quality of air quality forecasts for the public, EPA and NOAA are partnering to develop a national air quality forecasting model that will simultaneously protect public health and advance the science of air quality modeling.

Each year millions of people in the United States are exposed to unhealthy levels of air pollution. For many of them—especially children, outdoor workers, and those who suffer from asthma and other respiratory problems—knowing forecasted levels of pollution can make a significant difference in the quality of their lives and how they plan their daily activities. According to a recent study in southern California, air quality warnings by themselves produced 4–7% fewer hospital visits for children with asthma on poor air quality days.[1]

The rationale for air quality forecasting is that it provides the public with air quality information that can be used to make daily lifestyle decisions to protect health. Real-time and forecasted air quality information plays a very important role in informing the public about potentially harmful conditions. This information allows people to take precautionary measures to avoid or limit their exposure to predicted unhealthy levels of air quality. For example, in the most recent *Roper Green Gauge Report*, conducted by RoperASW and based on a nationwide poll of more than 2000 people, 52% of those surveyed said they had heard of "ozone days" or "code orange"/"code red" air quality days and 46% said they had reduced their exposure to air pollution by modifying outdoor exercise or work habits.[2] Code orange and code red days are days when air quality levels are forecasted to be in the "unhealthy" ranges and above the limits set by the National Ambient Air Quality Standards (NAAQS).

In addition, many communities have initiated air quality "action" or "awareness" days, based on air quality forecasts, to implement voluntary programs to reduce pollution and improve local air quality. According to the *Roper Green Gauge Report*, 37% of those people who had heard of ozone days or code orange/code red air quality days attempted to reduce the amount of air pollution through some voluntary measure, such as car pooling or taking public transportation. Washington, DC, for example, has seen a 10% increase in public transportation ridership on air quality alert days versus normal days due to free bus rides that are offered by the city on code red air quality days.[3]

Since 1997, the U.S. Environmental Protection Agency (EPA) has partnered with state and local air agencies to voluntarily provide real-time and forecasted air quality information to the public through EPA's AIRNow program. AIRNow utilizes the 1997 revised Air Quality Index (AQI)[4] reporting rule, linking air quality concentrations and associated health effects to a simple color-coded index that can be easily and consistently reported to the public. Originally developed under EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) initiative, AIRNow is the focal point for current air quality conditions and forecasts for the United States and Canada. The program collects real-time ozone air quality data from more than 1200 monitors in 42 states, Canada, and the District of Columbia, and air quality forecasts for more than 250 cities across the United States. AIRNow also collects real-time fine particle ($PM_{2.5}$) air quality data for nearly 200 continuous monitors in 27 states and the District of Columbia.

Air quality is driven by two key factors: meteorology and pollutant emissions. Air quality forecasting is difficult because it depends not only on weather predictions, but also on predicting how the weather affects pollutant emissions, chemical reactions, pollutant transport, and the fate of pollutants. Air quality forecasting relies on measuring and predicting the atmospheric state and also determining the spatial-temporal patterns of biogenic and anthropogenic emissions. Various forecasting tools exist to predict future air quality concentrations, ranging from simple rules of thumb to statistical methods to photochemical models. Other key needs for air quality forecasting include infrastructure to collect real-time air quality data from agencies across the United States and methods to disseminate this information to the public and media.

Equally important are education and outreach programs to inform the public about air quality problems, health effects, interpretation of air quality forecasts, and actions to reduce exposure and emissions.

Air quality forecasting is not new. Los Angeles has been providing air quality forecasts for more than 30 years. However, only recently have operational air quality forecasts become routine for most of the United States. In the past five years, for example, the number of cities providing air quality forecasts collected by EPA's AIRNow program has increased from 30 to more than 250. Similarly, forecasting methods are transiting from simple rule-of-thumb and statistical methods to more complex dynamic grid-based models. In many ways, the state of air quality forecasting today is similar to that of weather forecasting 20–30 years ago.

The accuracy of air quality forecasts has not been assessed uniformly throughout the agencies now conducting them, partly due to the decentralized nature of these agencies. However, most air quality agencies verify their forecasts daily and at the end of each season using a variety of verification metrics, although these are not widely published in the open literature. The types of verification depend on the objectives of local air quality forecasting programs (e.g., health protection, ozone action day planning).

Some of the challenges facing air quality forecasters in making more accurate and specific forecasts include

- developing better understanding and quantification of spatial and temporal emissions from both anthropogenic and biogenic sources;
- improving the resolution and accuracy of meteorological forecasts, particularly during weak synoptic forcing (i.e., stagnant, high pressure conditions); and
- developing air quality tools that provide higher spatial and temporal forecasts to provide the public with information about the location and duration of unhealthy air.

This article provides a detailed discussion of the current state of EPA's air quality forecasting activities, an explanation of the current process and the various aspects of making an AQI forecast useful to the public, the agency's short-term plans to promote $PM_{2.5}$ forecasting, EPA's initial activities under the partnership with the National Oceanic and Atmospheric Administration (NOAA), and the future directions for air quality forecasting programs.

EPA–NOAA PARTNERSHIP

Several different forecasting approaches are currently used by state and local air agencies, and many are providing very good results. However, there is a critical need for consistent, national air quality forecasting tools that can be added to the current suite of local prediction tools. To meet that need, EPA and NOAA are entering into a memorandum of agreement (MOA) to develop a national numerical air quality forecast model. The model will initially predict ozone and later, particulate matter (PM).

Both agencies bring a wealth of technical expertise and infrastructure to this partnership. EPA has run numerical photochemical models for many years, with a long history of research in air chemistry interactions, and has developed and refined emissions inventories for use in air quality models over the past 20 years. EPA also provides a scientific understanding of how air quality impacts human health and the environment. As the federal agency responsible for setting the National Ambient Air Quality Standards (NAAQS), EPA conducts extensive research in the field of health effects related to air quality. In addition, EPA provides educational and outreach materials related to air quality and associated health effects. EPA has a long history of working with state and local air agencies and provides a central repository for a decentralized ambient monitoring network via the historical Aerometric Information Retrieval Air Quality System (AIRS-AQS) and AIRNow programs. EPA collects and stores real-time air quality monitoring data from 89 state and local air agencies for the AIRNow program.

NOAA has significant scientific expertise in numerical weather forecasting and meteorological modeling. Having accurate, high-resolution predictions of atmospheric conditions is critical to predicting air quality levels. NOAA also has years of experience in operational forecasting, ensuring that the air quality forecast model being developed operates in a reliable and systematic fashion. This will greatly enhance the ability to quickly generate forecast concentrations that will assist state and local forecasters in developing AQI forecasts and issuing local air quality alerts and warnings.

The basic intent of the MOA between NOAA and EPA is to identify the roles and responsibilities of each agency. As a result of the MOA, EPA will be responsible for the delivery of hourly ambient air quality concentrations and a current national emissions inventory for use in air quality forecasting model development. EPA will also be responsible for delivery of and periodic updates to the air chemistry model to be used in NOAA's air quality forecasting model. NOAA will have primary responsibility for development of the meteorological model, as well as the daily operations of the air quality forecast model. EPA will coordinate dissemination of the model forecasts and their associated health messages with state and local air agencies and print, television, and Internet media outlets.

This partnership represents an excellent opportunity for two federal agencies to work together to provide air quality forecasts that can concurrently protect public health and advance the science of air quality modeling. It will also provide better tools for state and local agencies, improving their current air quality forecast capabilities. The national forecast model will also provide air quality forecasts for areas where forecasts were

previously unavailable. It will provide a real-time scientific laboratory for air quality modeling with daily model simulations that can be evaluated continuously. Not only will this partnership enhance future air quality forecasting capabilities, but it will also enhance future regulatory modeling through the development of better models, emissions inventories, and air quality databases.

CURRENT STATE OF EPA AIR QUALITY FORECASTING ACTIVITIES

Health Effects and Exposure

Over the past 30 years, EPA has partnered with major universities and institutions to conduct research on the health effects of criteria pollutants. Health effects studies have shown the impacts of air pollution on children, adults, and the elderly. Such studies are used to establish national air quality standards and to determine AQI thresholds and cautionary language to accompany AQI forecasts. Air quality forecasts, combined with public awareness programs such as the AQI, allow the public to make informed choices about reducing their exposure to air pollution. By linking forecasted pollutant concentrations to the AQI, each forecast carries a health effect message and suggested actions to reduce exposure. Ongoing health effects research is critical to the air quality forecasting program because it ensures that the latest health effects information is available for incorporation into the AQI.

Monitoring and Data Collection

Monitoring Support for State and Local Agencies. To assess the quality of the air and to ascertain compliance with and progress toward meeting ambient air quality standards, EPA has developed, and continues to upgrade, an ambient air quality monitoring program to measure criteria pollutants (particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, lead). EPA's ambient air quality monitoring program, carried out by state and local agencies, consists of three major categories of monitoring stations: State and Local Air Monitoring Stations (SLAMS), National Air Monitoring Stations (NAMS), and Special Purpose Monitoring Stations (SPMS). Additionally, a fourth category of monitoring stations, the Photochemical Assessment Monitoring Stations (PAMS), measures ozone precursors (approximately 60 volatile hydrocarbons and carbonyl compounds), as required by the 1990 Clean Air Act Amendments.

Originally, data from this network, which are critical for communicating current air quality conditions and forecasting air quality, were not available in real time from a centralized system. However, through the 1996 EMPACT initiative, EPA established the AIRNow program and provided funds to state and local agencies to purchase additional monitors and associated equipment for transmitting real-time measurements.

Table 1. AQI values, categories, and pollutant concentration thresholds for ozone, $PM_{2.5}$, and PM_{10}. Concentration breakpoints for other pollutants are available.[2]

AQI	AQI Category	O_3 (8 hr ppb)[a]	O_3 (1 hr ppb)	$PM_{2.5}$ (μg/m^3)	PM_{10} (μg/m^3)
0–50	Good	0–64	–	0–15	0–54
51–100	Moderate	65–84	–	16–40	55–154
101–150	Unhealthy for sensitive groups	85–104	125–164	41–65	155–254
151–200	Unhealthy	105–124	165–204	66–150	255–354
201–300	Very unhealthy	125–374	205–404	151–250	355–424
301+	Hazardous	–[b]	405–604	251–500	425–604

[a]Areas are generally required to report the AQI based on 8-hr ozone values, however, there are a small number of areas where an AQI based on 1-hr ozone values would be more precautionary. In these cases, in addition to calculating the 8-hr ozone index value, the 1-hr ozone index value may be calculated and the maximum of the two values is reported; [b]when 8-hr ozone concentrations exceed 0.374 ppm, AQI values of 301 or higher must be calculated with 1-hr ozone concentrations.

Funding provided by the EMPACT program was earmarked solely for projects that provided real-time environmental data to the public.

The Air Quality Index. Under the Clean Air Act (CAA), EPA was required to establish a nationally uniform air quality index for reporting air quality data to the public. In 1997, the Pollutant Standards Index was redeveloped in conjunction with the latest health effects information. The resulting AQI provides a simple, uniform system to report levels of the criteria pollutants regulated under the CAA. The AQI links health to air quality concentrations, providing the public with timely, easy-to-understand information about air quality. The AQI converts a measured pollutant concentration to a number on a scale of 0 to 500, as shown in Table 1. The AQI value of 100 corresponds to the NAAQS established for the pollutant under the CAA. An AQI above 100, therefore, indicates that the air is unhealthy and poses a health concern.

The AIRNow Program

EPA's AIRNow program is built on the existing network of ozone monitors throughout the country. These monitors have historically been used to provide quarterly reports to AIRS-AQS. While AIRS-AQS remains the most complete and comprehensive air quality database in the United States, it offers no real-time access and is relatively difficult for the general public to access and navigate. The AIRNow program was created to address this deficiency. The initial focus of AIRNow was to provide real-time ozone maps, as shown in Figure 1, to the public via the Internet. The graphical

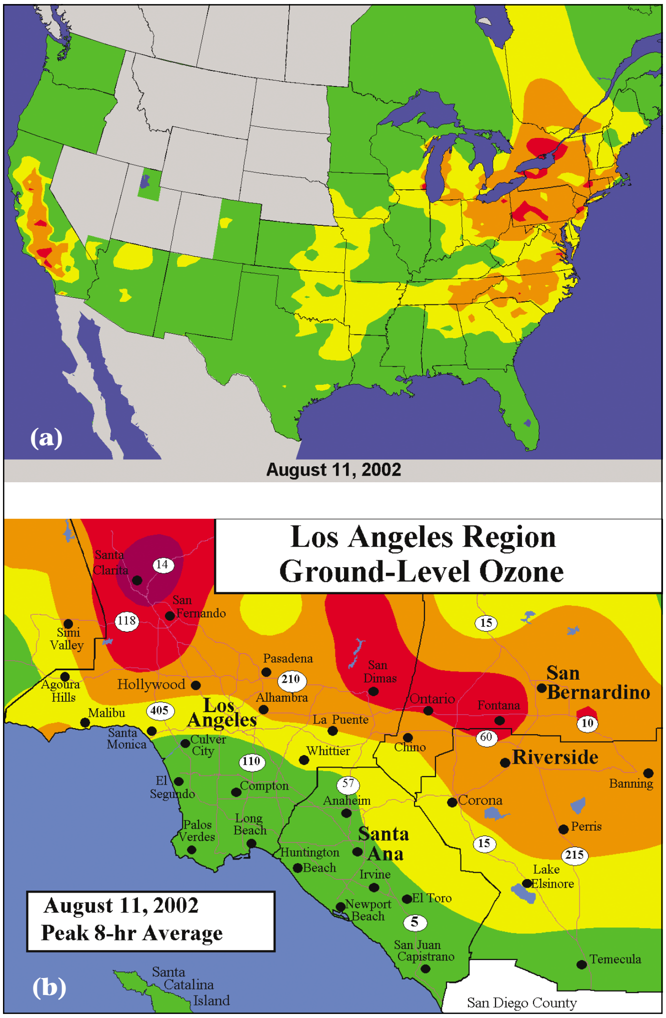

Figure 1. Example of daily peak AQI maps from the AIRNow program showing (a) a national map and (b) a local map of Los Angeles on August 11, 2002.

nature of the ozone maps and the easy-to-understand AQI color categories enables the public to easily comprehend current ozone concentrations. The program collects air quality data on an hourly basis from 89 state and local agencies (see Table 2). Using AIRNow data, air quality forecasters can help predict long-range transport of ozone by examining upwind ozone concentrations shown on the AIRNow maps. Today, state and local agencies submit daily air quality forecasts for more than 250 cities to AIRNow.

AIRNow is the national repository of real-time air quality data and forecasts. A central Data Management Center (DMC) allows agencies to submit air quality data on an hourly basis. At the DMC, the data first undergo automated quality control checks that guard against erroneous values. Next, the DMC converts the data to the AQI and produces more than 50 animated contour maps, covering local, regional, and national areas, and sends the maps to EPA's public Web server. The entire process, from initial data collection to publicly available maps, occurs in less than one hour. The local forecasts are posted hourly on the AIRNow Web site (*www.epa.gov/airnow*).

The AIRNow program developed the infrastructure needed to collect, verify, and distribute real-time air quality data necessary for forecasting air quality. In addition, AIRNow created methods to collect locally produced air quality forecasts and disseminate them to the public via media outlets. The program distributes real-time and forecasted air quality data to weather service providers (WSPs), private companies that supply weather data to print, television, and Internet media outlets, which, in turn, can present viewers with current ozone conditions during live weather broadcasts.[5]

State and Local Ozone and $PM_{2.5}$ Forecasting Efforts

State and local air quality agencies are now forecasting air quality for more than 250 cities, as shown in Figure 2. Most agencies employ an air quality meteorologist, or a team of meteorologists, and using a range of forecasting tools combined with practical experience, issue predictions for peak ozone levels expected during the current and next-day periods. Some agencies (e.g., Los Angeles, San Francisco, New York, Texas) have been forecasting local air quality for more than a decade, while other agencies have only recently begun predicting ozone. Some agencies are also beginning to forecast $PM_{2.5}$ since the promulgation of the new PM standards, which require deployment of continuous (hourly) $PM_{2.5}$ monitors.

Air quality episodes are affected by local/regional meteorology and emissions sources that vary spatially and temporally. Consequently, air quality forecasting tools and techniques have been developed to focus on these local phenomena. Air quality forecasting encompasses a range of techniques, including

- **Criteria** (rules of thumb)—Criteria use thresholds of forecasted weather variables to predict future pollutant concentrations. For example, high ozone concentrations often occur with hot temperatures. Historical analysis might reveal that days with temperatures above 90 °F tend to have peak 8-hr ozone concentrations greater than 85 ppb.
- **Parametric methods** (statistics, neural networks, fuzzy logic)—Parametric methods create objective relationships between forecasted meteorology and predicted pollutant concentrations. Multivariate regression equations have been successfully used to forecast peak ozone concentrations in many areas of the country.[6-9]
- **Photochemical models**—Photochemical models are a collection of computer algorithms that simulate the three-dimensional atmospheric and chemical processes that influence pollutants, including transport, dispersion, and chemistry. Key inputs to the model include an emissions inventory, meteorological predictions, and initial and boundary conditions for chemistry. In the late 1990s, organizations in

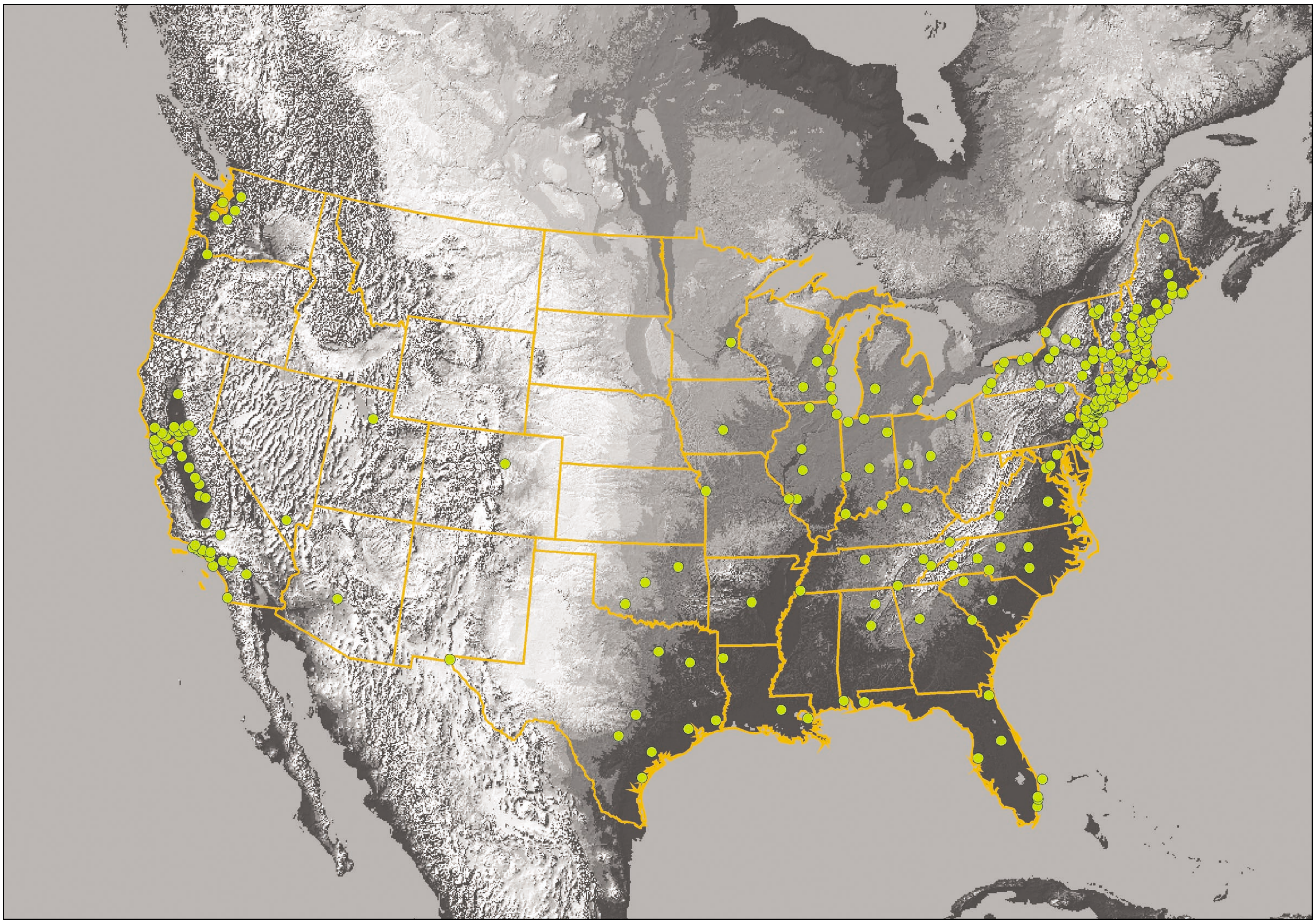

Figure 2. U.S. cities where ozone and/or $PM_{2.5}$ concentrations are predicted on a daily basis by state and local air quality agencies.

the United States and internationally began running these models in a real-time mode to produce calculated numerical fields for predicted ozone concentrations.[10-12]

- **Experience**—Experience gained by day-to-day forecasting, similar to weather forecasting, plays a large part in accurately predicting air quality and helps balance the limitations of the other methods noted above.

Education of the Public and the Media

To help improve the accuracy of air quality forecasts submitted to the AIRNow program, EPA provides educational tools and technology transfer to state and local agencies. Educational projects include forecasting guidance documents[13] for ozone and $PM_{2.5}$ and short courses in air quality forecasting given at annual conferences.[14] These training courses are comprehensive and may be provided as Web-based teaching units in the future. Technology transfer projects include several pilot forecasting projects, developing both statistical and photochemical models and conducting pilot forecasting, and then transferring the tools and knowledge to state and local agencies. Several ozone and $PM_{2.5}$ forecasting pilot projects have been conducted in different airsheds, seasons, and locales to gain a better understanding of the various parameters that affect air quality conditions.

While developing the technical tools and skills to provide air quality forecasts is a major component of EPA's AIRNow program, providing educational materials and training for state and local air quality offices and the general public on the health effects of air quality is just as critical. EPA has developed numerous brochures on the AQI,[15] ozone health effects,[16,17] and the differences between ground-level ozone and stratospheric ozone,[18] as well as guidance for state and local forecasters on how to deliver AQI forecasts to the public.[19] The public must be able to understand the relationship between air quality and health so that forecasts can be used to make health-based decisions. EPA coordinates directly with WSPs in data delivery and AQI product development and communicates regularly with national media outlets in an effort to provide feedback on AQI messaging and presentation and new or improved AQI products. EPA also provides air quality and AQI education to media specialists.

For the past four years, EPA's annual National Air Quality Conference has included sessions with the media and public

Table 2. Local, state, regional, and federal air quality agencies participating in EPA's AIRNow program.

Alabama Department of Environmental Management (AL)
Albuquerque Environmental Health Department (NM)
Allegheny County (PA)
Arkansas Department of Environmental Quality (AR)
Broward County (FL)
California Air Resources Board (CA)
Chattanooga–Hamilton County Air Pollution Control Bureau (TN)
Cherokee Nation
Clark County Department of Air Quality Management (NV)
Colorado Department of Public Health and Environment (CO)
Connecticut Department of Environmental Protection (CT)
Delaware Department of Natural Resources and Environment (DE)
Department of Health—Environmental Health Administration—AQ Division (DC)
Duval County (FL)
Environment Canada
Florida Department of Environmental Protection (FL)
Forsyth County Environmental Affairs Department (NC)
Georgia Department of Natural Resources (GA)
Greater Vancouver Regional District (Canada)
Hawaii State Department of Health (HI)
Hillsborough County (FL)
Idaho Department of Environmental Quality (ID)
Illinois Environmental Protection Agency (IL)
Indiana Department of Environmental Management (IN)
Indianapolis Public Works—Air Pollution Control Division (IN)
Iowa Department of Natural Resources (IA)
Jefferson County Air Pollution Control District (KY)
Jefferson County Department of Health (AL)
Kansas Department of Health and Environment (KS)
Kentucky Department of Natural Resources and Environmental Protection (KY)
Knox County Department of Air Quality Management (TN)
Lake Michigan Air Directors Consortium
Lane Region Air Pollution Authority (OR)
Linn County Public Health (IA)
Louisiana Department of Environmental Quality—Baton Rouge (LA)
Louisiana Department of Environmental Quality—New Orleans (LA)
Louisiana Department of Environmental Quality—Shreveport (LA)

Table 2. (cont.)

Maine Department of Environmental Protection (ME)
Mid-Atlantic Regional Air Management Association
Maricopa County Environmental Services (AZ)
Maryland Department of Environment (MD)
Massachusetts Department of Environmental Protection (MA)
Mecklenburg County Department of Environmental Protection (NC)
Memphis/Shelby County Health Department (TN)
Metropolitan Washington Council of Governments (DC)
Michigan Department of Environmental Quality (MI)
Minnesota Pollution Control Agency (MN)
Mississippi Department of Environmental Quality (MS)
Missouri Department of Natural Resources (MO)
Mojave Desert Air Quality Management District (CA)
Nashville and Davidson County Health Department—PCD (TN)
National Park Service
Northeast States For Coordinated Air Use Management
New Hampshire Department of Environmental Services (NH)
New Jersey Department of Environmental Protection (NJ)
New Mexico Air Quality Bureau (NM)
New York Department of Environmental Conservation (NY)
North Carolina Department of Environment and Natural Resources (NC)
Northern Sierra Air Quality Management District (CA)
Ohio Environmental Protection Agency (OH)
Oklahoma Department of Environmental Quality (OK)
Oregon Department of Environmental Quality (OR)
Pennsylvania Department of Environmental Protection (PA)
Philadelphia Air Management Services (PA)
Pima County Department of Environmental Quality (AZ)
Pinellas County Environmental Management (FL)
Placer County Air Pollution Control District (CA)
Polk Co. Air Quality Division (IA)
Regional Air Pollution Control Agency—Dayton (OH)
Rhode Island Department of Environmental Management (RI)
Sacramento Metropolitan Air Quality Management District (CA)
San Diego Air Pollution Control District (CA)
San Francisco Bay Area Air Quality Management District (CA)
San Joaquin Valley Unified Air Pollution Control District (CA)
South Carolina Department of Health and Environmental Control (SC)
South Coast Air Quality Management District (CA)
Tennessee Department of Environment and Conservation (TN)
Tennessee Valley Authority—River System Operations & Environment (TN)
Texas Commission on Environmental Quality (TX)
Utah Department of Environmental Quality (UT)
Ventura County Air Pollution Control District (CA)
Vermont Air Pollution Control Division (VT)
Virginia Department of Environmental Quality (VA)
Washington Department of Ecology (WA)
Washoe County District Health Department (NV)
West North Carolina Regional Air Pollution Agency (NC)
West Virginia Division of Environmental Protection (WV)
Wisconsin Department of Natural Resources (WI)
Yolo–Solano Air Quality Management District (CA)

outreach specialists from EPA and state and local agencies. These sessions provide an opportunity for forecasters and public outreach and media specialists to share information and better understand how forecasts are used to inform the public. State and local agencies, in turn, pass educational materials on to the local media and their constituents. Air quality forecasts alone are useless if the public does not understand their meaning and what actions need to be taken to reduce their exposure to unhealthy air.

The educational component of this program is not limited to health effects. One of the many benefits of air quality forecasting is the opportunity for people to take positive actions that will reduce pollution on forecasted poor air quality days.[20] EPA works closely with state and local agencies to provide educational materials about the many voluntary measures that can take to reduce air pollution. EPA's Office of Transportation and Air Quality, for example, has had great success in promoting voluntary reduction programs through air quality "action" or "alert" days. These voluntary efforts can decrease pollution by reducing the emissions that react to form ozone and PM.

Emissions Inventory Research

Analyzing the effects of emissions on air quality has been a major component of EPA's regulatory modeling for more than 20 years. As a result, EPA has done extensive research into the development and improvement of emissions inventories and emissions modeling. Most inventories reflect annual emissions estimates. Calculating the hourly estimates needed to feed air quality models requires substantial processing and manipulation.

EPA has a long history of developing and implementing emissions modeling, from the Flexible Regional Emissions Data System (FREDS) used in the 1980 National Acid Precipitation Assessment Program (NAPAP) to the current Sparse Matrix Operator Kernel Emissions (SMOKE) system. Through its Office of Atmospheric Programs, the agency has access to hourly continuous emissions data from all major electricity generators across the United States, while the Office of Transportation and Air Quality provides access to the latest mobile emissions modeling tools. An accurate air quality model will depend heavily on the underlying emissions inventories and modeling.

Chemistry Research

While emissions inventories are critical inputs to an air quality modeling system, understanding atmospheric chemistry and the multitude of chemical reactions that occur in an air quality model is equally critical. EPA has developed numerous regional Eulerian grid models over the past 20 years, including the Regional Acid Deposition Model,[21] the Regional Oxidant Model,[22] and the Community Multiscale Air Quality model

(CMAQ).[23] The CMAQ model is a community-based model that represents the current state-of-the-science in air quality modeling. Working in concert with NOAA scientists, EPA has coordinated the development of these models, employing many of the leading air quality scientists from universities and the private sector.

EPA will continue to provide high-level research and development of improved chemical mechanisms for air quality models. The science of atmospheric chemistry, the relationships between meteorology and chemistry, and the resulting chemical reactions continue to evolve. As research advances in these areas, EPA will work with NOAA to implement new algorithms, bringing improved science into the forecast model.

FUTURE DIRECTIONS

Near-Term Forecast Activities (2002–2004)

The science of air quality forecasting continues to advance. EPA and NOAA's planned national air quality forecast model for ozone will add another layer by providing another forecasting tool to improve the forecasted spatial and temporal concentrations of air pollutants. The longer-term inclusion of PM in the forecast model will likely prove even more beneficial as the understanding of the science behind aerosols improves and the development of numerical models for fine particles evolves. In the meantime, supporting the numerous local air quality forecast programs across the United States remains a priority. EPA will continue to provide resources, guidance, and training in support of air quality forecasting efforts of state and local agencies. In the future, EPA will expand the forecasting season from primarily summertime ozone to year-round with the inclusion of PM.

In August 2002, EPA began an effort to initiate $PM_{2.5}$ forecasting and real-time data reporting for 36 major cities across the United States. This effort is geared toward providing air quality forecasting tools and hands-on support and training for those 36 cities, as well as technical support in the reporting and data management of real-time $PM_{2.5}$ data. This program will assist state and local air agencies in developing reliable $PM_{2.5}$ forecasting. In September 2003—September is the traditional end of the ozone season for most of the country—EPA expects year-round AQI forecasts to continue for these 36 cities and perhaps others, as the technical knowledge and experience is shared. This will lay the groundwork for the geographic expansion of year-round, multipollutant forecasting in 2004 and beyond.

Near-Term Forecast Model Development Activities (2002–2004)

While the near-term efforts to promote forecasting continue, EPA will also be preparing for its role in partnership with NOAA to develop an operational forecast model. Initial work, focused on the eastern United States, will include development of accurate and timely emissions inventories and fully integrated distribution of the real-time air quality data between EPA and NOAA. As the operational aspects of the air quality forecast model come to light, EPA will work closely with NOAA to conduct research and develop better approaches to model air chemistry, as well as to enhance the interactions between meteorological models and emissions inventories. Developing improved temporal factors that will model day-to-day variations more accurately than annual inventories is key to improving overall model accuracy.

Coordinating the important roles of state and local air agencies will be a critical function for EPA during the early stages of the partnership to develop the operational model. State and local air agencies provide many of the inputs for a national air quality model, including real-time air quality data and emissions inventories. In addition, as the final cog in the process, state or local forecasters have the authority to issue AQI forecasts and, likewise, air quality alerts, warnings, or action days. The need for close coordination among EPA, the National Weather Service (NWS) and state and local agencies is critical. The NWS system for quickly disseminating weather information to the public will be very useful. EPA will coordinate the public distribution of AQI forecasts with the collaboration of state and local agencies, the NWS, the AIRNow program, and media outlets partners.

Finally, as the work moves forward to provide an operational model, it is imperative that EPA and NOAA work closely to continue to educate the public and media about air quality forecasts. In particular, with multipollutant forecasting, the health message becomes more complex, dictating that public and media messages have to be very clear. For example, a summer day may have both high ozone and high PM, yet at different times of the day. Communicating that day's air quality and exposure avoidance actions is much more difficult than on days when only ozone or PM may be high. In addition, with the development of a national forecast model, some inexperienced state or local agencies will be conducting AQI forecasts for the first time. Therefore, it will be very important to work with agency forecasters on issues, such as what the AQI forecast represents, what are forecast uncertainties, and what actions individuals could take to limit exposure on high pollution days.

2005 and Beyond

As the development of the operational model evolves, EPA and NOAA will continue to use their 45-year relationship to enhance and improve technical forecasting tools. While the initial operational model will focus on ozone in the eastern United States, the long-term direction is toward a national air quality forecast model for both ozone and $PM_{2.5}$. The science of $PM_{2.5}$ is still emerging, so the development of any numerical air

quality forecasting model will be a necessary work in progress. Even after NOAA begins providing daily operational model predictions, EPA and NOAA scientists will continue to seek better approaches for modeling PM. In addition, as next-generation weather forecast models are finalized by NOAA, they too can be integrated into the operational air quality modeling system.

As well as predicting PM, long-term priorities include better temporal and longer-range forecasts (beyond three days). Providing air quality forecasts for different times of the day, as well as for multiple days, will be beneficial to the public and the media. Limiting exposure does not have to mean staying indoors all day during a forecasted poor air quality day, especially if the conditions are better in the morning (as is often the case with summertime ozone) or in the afternoon (with wintertime PM). The ability to accurately predict when air quality levels will rise and fall will be a significant step toward improving the protection of public health.

Finally, advancements in air quality forecasting will provide tremendous benefits to the regulatory community. Faster, more accurate forecast models will provide policy-makers with the ability to examine, in a more timely fashion, alternative approaches for reducing future-year emissions. In addition, numerical model simulations for 365 days per year, and the ability to evaluate and verify those models in multiple meteorological situations, will be invaluable to scientists performing research in the field of atmospheric chemistry and modeling.

A great deal of work, from many contributors, remains before the public will reap the many benefits of this effort. If the past relationship and successful partnership between EPA and NOAA is any indication of the success of this effort, there will be better forecasts in the future for everyone.

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